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(12) -

# EUROPEAN PATENT APPLICATION

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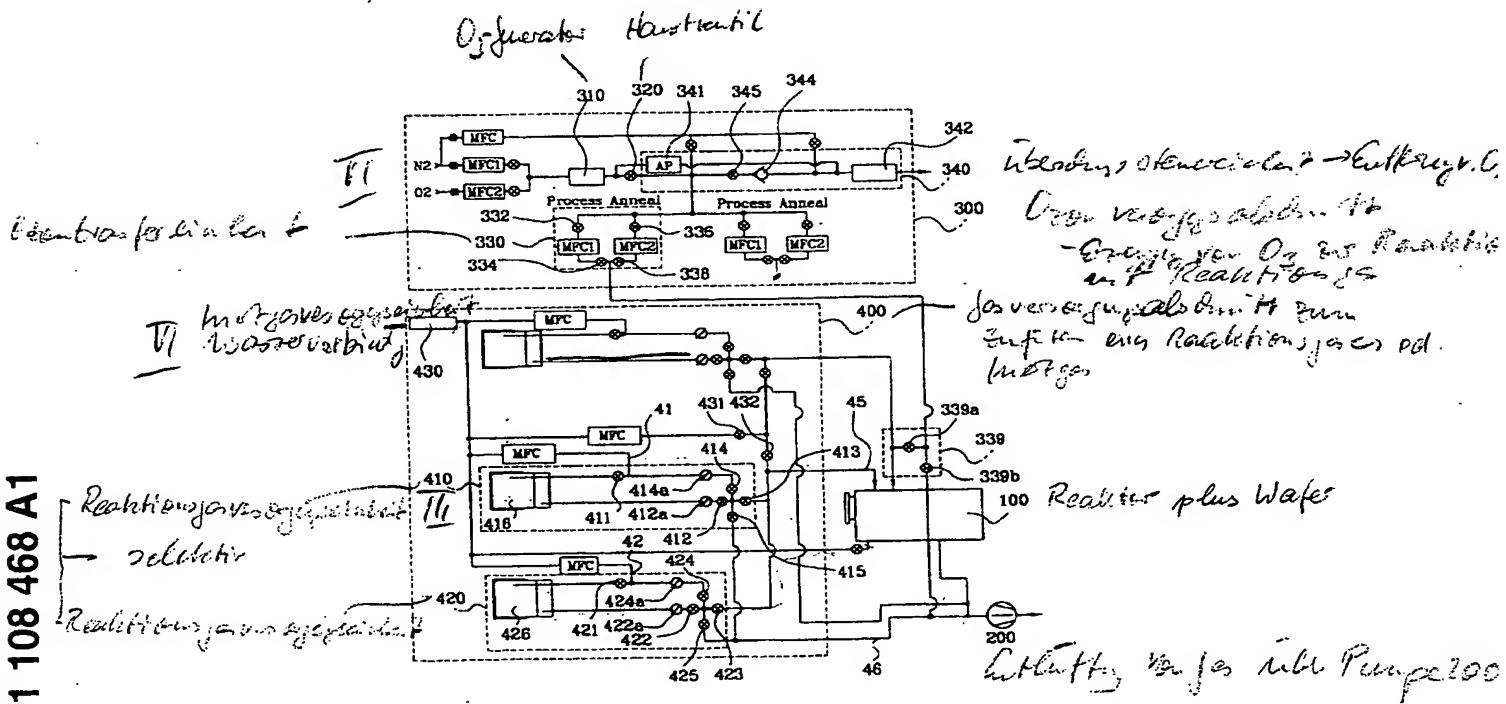
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Pyungtaek-si, Kyungki-do (KR)

## (54) Thin film deposition apparatus

(57) A semiconductor thin film deposition apparatus having at least one reactor (100) in which a wafer is received, a gas supply portion (400) for supplying a reaction gas or inert gas to the reactor, and an exhaust pump

(200) for exhausting gas from the reactor (100), characterized in that the improvement comprises an ozone supply portion (300) for generating ozone as a gas that reacts with the reaction gas, and for supplying the ozone to the reactor (100).

FIG. 1



EP 1 108 468 A1

**Description****BACKGROUND OF THE INVENTION****1. Field of the Invention**

**[0001]** The present invention relates to a thin film deposition apparatus for a semiconductor, and more particularly, to a semiconductor thin film deposition apparatus which can deposit a thin film, for example, an aluminum oxide film, on a wafer using ozone and also perform thermal treatment using ozone.

**2. Description of the Related Art**

**[0002]** General thin film deposition apparatuses for depositing a thin film on a wafer use deionized (DI) water vapor as a reaction gas for oxidation. For example, an aluminum oxide film can be formed at a thickness of an atomic layer by continuously introducing DI water vapor and TriMethylAluminum (TMA) gas into a reactor on which a wafer is loaded, and subsequently purging the introduced DI water vapor and TMA reaction gas.

**[0003]** However, when DI water vapor is used, an O-H group exists within a thin film, for example, an aluminum oxide film, formed by a thin film deposition process or by thermal treatment, thus degrading the characteristics of the thin film. That is, H existing in the thin film causes damage to the thin film, thereby degrading the characteristics of the thin film.

**SUMMARY OF THE INVENTION**

**[0004]** To solve the above problem, an objective of the present invention is to provide a semiconductor thin film deposition apparatus in which the use of ozone as a reaction gas for oxidation prevents defects from being generated within a thin film deposited on a wafer.

**[0005]** To achieve the above objective, the present invention provides a semiconductor thin film deposition apparatus having at least one reactor in which a wafer is received, a gas supply portion for supplying a reaction gas or inert gas to the reactor, and an exhaust pump for exhausting gas from the reactor, characterized in that the improvement comprises an ozone supply portion for generating ozone as a gas that reacts with the reaction gas, and for supplying the ozone to the reactor.

**BRIEF DESCRIPTION OF THE DRAWINGS**

**[0006]** The above objective and advantages of the present invention will become more apparent by describing in detail a preferred embodiment thereof with reference to the attached drawings in which:

FIG. 1 is a schematic diagram of one embodiment of the semiconductor thin film deposition apparatus according to the present invention.

**DESCRIPTION OF THE PREFERRED EMBODIMENT**

**[0007]** Referring to FIG. 1, a semiconductor thin film deposition apparatus according to the present invention

5 includes at least one reactor 100 in which a wafer (not shown) is received, an exhaust pump 200 for exhausting gas from the reactor 100, an ozone supply portion 300 for generating ozone that is supplied to the reactor 100, and a gas supply portion 400 for generating a reaction gas or inert gas that is supplied to the reactor 100. This thin film deposition apparatus uses ozone for being reacted with the reaction gas to deposit a thin film on a wafer.

**[0008]** The semiconductor thin film deposition apparatus may further include a heater (not shown) as a thermal treatment means for performing thermal treatment on a wafer received in the reactor 100. The heater can control the temperature of the reactor in a range of 300 to 700 EC.

**[0009]** The ozone supply portion 300 includes an ozone generator 310, a main valve 320 connected to the ozone generator 310 for allowing ozone to flow or for blocking the flow of ozone, an ozone transfer unit 330 for transferring ozone, which has passed through the main valve 320, to the reactor 100, and an ozone control unit 340 for allowing a certain amount of ozone to flow to the ozone transfer unit 330 when an excessive amount of ozone is generated by the ozone generator 310.

**[0010]** The ozone transfer unit 330, for guiding ozone generated by the ozone generator 310 to the reactor 100, is designed so that ozone used in a thin film deposition process for a wafer received within the reactor 100 is transferred separately from ozone used in thermal treatment on the wafer. That is, the ozone transfer unit 330 is connected to the main valve 320 in parallel, and includes a process ozone transfer member for transferring ozone used for a thin film deposition process, a thermal treatment ozone transfer member for

40 transferring ozone used for thermal treatment. A selection transfer member 339 selectively transfers ozone which has passed through the process ozone transfer member or thermal treatment ozone transfer member, to the reactor 100 or exhaust pump 200. In FIG. 1, two ozone transfer units are shown. However, the other transfer unit will not be described because it has the same structure as the above-described ozone transfer unit 330. If several ozone transfer units described above are used, an equal number of reactors can be operated.

**[0011]** The process ozone transfer member is made up of a first process valve 332, a process mass flow controller (MFC1), and a second process valve 334, which are sequentially connected.

**[0012]** The thermal treatment ozone transfer member is made up of a first thermal treatment valve 336, a thermal treatment mass flow controller (MFC2), and a second thermal treatment valve 338, which are sequentially connected.

[0013] The selection transfer member 339 is made up of a first selection valve 339a and a second selection valve 339b. The first selection valve 339a is connected to a line between the second process valve 334 and the second thermal treatment valve 338, and the reactor 100, and allows or blocks the flow of ozone to the reactor 100. The second selection valve 339b is connected to a line between the second process valve 334 and the second thermal treatment valve 338, and the exhaust pump 200, and allows or blocks the flow of ozone to the exhaust pump 200. If the second selection valve 339b is opened, ozone which has passed through the second process valve 334 and the second thermal treatment valve 338 is applied to the exhaust pump 200. The first and second selection valves 339a and 339b perform opposite operations at the same time. That is, when the first selection valve 339a is turned off, the second selection valve 339b is turned on, and vice versa.

[0014] The process MFC1 and the thermal treatment MFC2 control the flow of ozone. The process MFC1 controls the flow of ozone used in a thin film deposition process in a range of 100 to 500 sccm (standard cc/min). The thermal treatment MFC2 controls the flow of ozone used for thermal treatment up to 20000 sccm.

[0015] It is not easy to control the amount of ozone generated by the ozone generator 310 in an the exact amount actually used in a thin film deposition process or thermal treatment. In practice, a small amount of ozone is used in a deposition process or thermal treatment process. However, the ozone generator 310 generally generates an excessive amount. Thus, a high ozone pressure is applied to a line connected between the ozone generator 310 and the main valve 320. When an excessive ozone pressure is applied to the line, even the MFC1 and MFC2 cannot properly control the flow of ozone. In this case, the ozone control unit 340 is operated.

[0016] The ozone control unit 340 includes an automatic pressure valve 341 and an ozone remover 342 which are installed on the line between the main valve 320 and the ozone generator 310. The automatic pressure valve 341 is automatically opened when the ozone pressure is equal to or greater than a predetermined value, and the ozone remover 342 removes ozone which has passed through the automatic pressure valve 341. For example, the ozone remover 342 can be a catalyzer that converts harmful ozone to harmless oxygen or another gas through a catalyzed chemical reaction and then exhausts the resultant gas. The ozone control unit 340 further includes a valve 345 and a check valve 344 which are installed on the line between the main valve 320 and the ozone remover 342. The valve 345 allows/ blocks the flow of ozone, and the check valve 344 allows ozone having a predetermined pressure or greater to flow only toward the ozone remover 342.

[0017] When an excessive ozone pressure is applied to the line due to an increase in the amount of ozone generated by the ozone generator 310, the pressure is

fed back to operate the ozone control unit 340. That is, when the ozone pressure is equal to or greater than a predetermined value, the pressure valve 341 is opened, so that a superfluous amount of ozone flows toward the ozone remover 342. Also, in the ozone remover 342, the introduced ozone is converted into harmless gas by a catalyst, and then the harmless gas is exhausted.

[0018] The ozone control unit 340 can maintain the pressure of ozone flowing into the ozone transfer unit 330 to be uniform, and thus can guide ozone at a stable state.

[0019] In the ozone supply portion, ozone generated by the ozone generator 310 flows into the reactor 100 along a route starting from the main valve 320 to the first process valve 332, to the process MFC1, to the second process valve 334, to the first selection valve 339a, or along a route starting from the main valve 320 to the first thermal treatment valve 336, to the thermal treatment MFC2, to the second thermal treatment valve 338, to the first selection valve 339a. That is, ozone can be selectively allowed to flow into the reactor 100 by selectively turning on or off the first process valve 332 or the first thermal treatment valve 336. The first and second selection valves 339a and 339b perform opposite operations at the same time, so that when the first selection valve 339a is turned off, the second selection valve 339b is turned on. Hence, ozone is exhausted directly to the outside by the exhaust pump 200.

[0020] The gas supply portion 400 includes a first reaction gas supply unit 410 for supplying a first reaction gas to the reactor 100, a second reaction gas supply unit 420 for supplying a second reaction gas, and an inert gas supply unit 430 for supplying an inert gas used as a carrier gas or a purging gas.

[0021] The first and second reaction gas supply units 410 and 420, and the inert gas supply unit 430 are connected to each other by a pipe line, and several valves 411, 412, 413, 414, 415, 421, 422, 423, 424 and 425 are installed on the line. These valves are connected to a controller (not shown) to allow/block the flow of gas.

[0022] The first reaction gas supply unit 410 includes a first reaction material container 416 filled with a first liquid reaction material to be vaporized and used as a first reaction gas, a mass flow controller (MFC) for controlling the flow of a carrier gas for transferring the first reaction gas to the reactor 100, a first flow control valve 412a installed between the first reaction material container 416 and a valve 412, and a second flow control valve 414a installed between the MFC and the valve 414. The first and second flow control valves 412a and 414a consecutively control the flow of gas, and uniformly raise/maintain the vapor pressure of a gas introduced into the reactor 100. In this embodiment, argon is used as the inert carrier gas. However, various inert gases such as neon can be used instead of argon.

[0023] The second reaction gas supply unit 420 includes a second reaction material container 426 filled with a second liquid reaction material to be vaporized

and used as a second reaction gas, an MFC for controlling the flow of a carrier gas for transferring the second reaction gas to the reactor 100, a first flow control valve 422a installed between the second reaction material container 426 and the valve 422, and a second flow control valve 424a installed between the MFC and the valve 424. The first and second flow control valves 422a and 424a consecutively control the flow of gas, and uniformly raise/maintain the vapor pressure of a gas introduced into the reactor 100.

[0024] It is preferable that the first and second flow control valves 412a, 414a, 422a and 424a adopted in the first and second gas supply units 410 and 420 are meter valves or control valves. It is also preferable that the first and second flow control valves 412a, 414a, 422a and 424a are installed in front of the valves 412, 414, 422 and 424, and that the distance between a flow control valve and an adjacent valve is minimized in order to control the flow of gas at a stable constant pressure. The flow control valves 412a, 414a, 422a and 424a control the flow of gas by adjusting the cross-sectional area through which gas passes.

[0025] In the gas supply portion 400, if the valves 411, 412 and 413 are opened, a transfer gas introduced via a first supply line 41 and the valve 411 flows into the reactor 100 via a route from the flow control valve 412a, to the valves 412 and 413, to a reactor line 45, together with the first reaction gas of the first reaction material container 416.

[0026] Then, if the valves 414 and 415 are opened, a carrier gas introduced via the first supply line 41 is exhausted to the outside through a route from the second flow control valve 414a, to the valves 414 and 415, to an exhaust line 46, to the exhaust pump 200. The first and second flow control valves 412a and 414a consecutively control the flow of gas, uniformly raise/maintain the vapor pressure of a gas flowing into the reactor 100, and equalize the pressure of a gas applied to the reactor 100 with the pressure of a gas applied to the exhaust pump 200.

[0027] Next, an inert gas flows into the reactor 100 along a route from the valve 431 to the valve 432 to the reactor line 45, and exhausts a reaction gas that remains within the reactor 100.

[0028] Thereafter, the second reaction gas of the second reaction material container 426 is allowed to flow into the reactor 100 via a route from the first flow amount control valve 422a, to the valves 422 and 423, to the reactor line 45, along with the carrier gas introduced via a second supply line 42 and the valve 421. Then, if the valves 424 and 425 are opened, the carrier gas is exhausted to the outside via the route from the second flow amount control valve 424a, to the valves 424 and 425, to the exhaust line 46, to the exhaust pump 200. The first and second flow control valves 422a and 424a consecutively control the flow of gas, uniformly raise/maintain the vapor pressure of a gas flowing into the reactor 100, and equalize the pressure of a gas applied to the

reactor 100 with the pressure of a gas applied to the exhaust pump 200.

[0029] An inert gas flows into the reactor 100 along a route from the valve 431 to the valve 432 to the reactor line 45, and exhausts a reaction gas that remains within the reactor 100.

[0030] In this embodiment as shown in FIG. 1, two ozone transfer units are shown, and three reaction gas supply units are shown. However, only the ozone transfer unit 330 and two reaction gas supply units 410 and 420 have been described to simplify explanation.

[0031] Referring to FIG. 1, the operation of the semiconductor thin film deposition apparatus is described for forming an aluminum oxide layer as an example of a thin film. Thermal treatment using ozone is performed as a pre-process for easily depositing a thin film on a wafer. In the thermal treatment, the internal temperature of the reactor 100 is increased to a range of 300 to 700 EC, and ozone is supplied into the reactor 100. According to this thermal treatment, ozone generated by the ozone generator 310 is introduced into the reactor 100 via a route from the main valve 320, to the first thermal treatment valve 336, to the thermal treatment MFC2, to the second thermal treatment valve 338, and to the first selection valve 339a. It is preferable that the thermal treatment is performed at a temperature as high as possible to accelerate decomposition of ozone.

[0032] After the thermal treatment is performed, ozone and a reaction gas flow into a reactor at the same time or a time interval apart, in order to deposit an aluminum oxide film on a wafer. That is, ozone generated by the ozone generator 310 flows into the reactor 100 via a route from the main valve 320, to the first process valve 332, to the process MFC1, to the second process

valve 334, and to the selection valve 339a. Meanwhile, the first reaction gas of the first reaction material container 416 flows into the reactor 100 via a route from the flow control valve 412a, to the valves 412 and 413, and to the reactor line 45 along with a carrier gas introduced

via the first supply line 41 and the valve 411, as the valves 411, 412 and 413 are opened. The ozone and the first reaction gas flowing into the reactor 100 react with each other, so that an aluminum oxide film is deposited on the wafer.

[0033] Next, in order to purge the reactor 100, an inert gas flows into the reactor 100 via a route from the valve 431, to the valve 432 and to the reactor line 45 to exhaust the ozone and first reaction gas within the reactor 100.

[0034] Following this, a thin film deposition process is continuously performed by supplying the second reaction gas of the second reaction material container 426, together with ozone, into the reactor 100 through a similar operation to that described above. A thin film can be deposited at a thickness of an atomic layer by varying the inflow duration of a reaction gas or ozone. Also, an inert gas for purging is allowed to flow into the reactor between the times for introducing ozone and a reaction

gas.

[0035] When a predetermined thin film is deposited on a wafer, the internal temperature of the reactor is increased to a range of 300 to 700 °C, and ozone is supplied into the reactor. In this way, thermal treatment is performed.

[0036] It is preferable that the flow of ozone is made equal to those of the first and second reaction gases, in order to suppress a change in the pressure of a reactor due to the sequential inflow of ozone and first and second reaction gases.

[0037] As described above, in the semiconductor thin film deposition apparatus according to the present invention, a defectless thin film can be formed on a wafer using ozone instead of deionized (DI) water vapor for oxidation as in the prior art. That is, in contrast to the prior art, generation of an H group that can permeate into a thin film is prevented, so that defects in a thin film caused by H can be prevented.

[0038] Also, thermal treatment can be performed together with a thin film deposition process, leading to deposition of a high-quality thin film and a simple process.

### Claims

1. A semiconductor thin film deposition apparatus comprising:

at least one reactor (100) in which a wafer is received;  
a gas supply portion (400) for supplying a reaction gas or inert gas to the reactor;  
an exhaust pump (200) for exhausting gas from the reactor; and  
an ozone supply portion (300) for generating ozone as a gas that reacts with the reaction gas, and for supplying the ozone to the reactor.

2. The semiconductor thin film deposition apparatus of claim 1, wherein the ozone supply portion comprises:

an ozone generator (310);  
a main valve (320) for allowing ozone to flow or for blocking the flow of ozone;  
at least one ozone transfer unit (330) for transferring ozone, which has passed through the main valve, to the reactor; and  
an ozone control unit (340) for allowing a certain amount of ozone to flow to the ozone transfer unit when an excessive amount of ozone is generated by the ozone generator.

3. The semiconductor thin film deposition apparatus of claim 2, wherein the ozone transfer unit (330) comprises:

a process ozone transfer member for transferring ozone used in a thin film deposition process; and  
a thermal treatment ozone transfer member for transferring ozone used in a thermal treatment process.

4. The semiconductor thin film deposition apparatus of claim 3, wherein the ozone transfer unit further comprises:

a selection transfer member for selectively transferring ozone which has passed through the process ozone transfer member or the thermal treatment ozone transfer member, to the reactor or the exhaust pump.

5. The semiconductor thin film deposition apparatus of claim 4, wherein the selection transfer member comprises:

a first selection valve connected to a line between the process ozone transfer member and the thermal treatment ozone transfer member and the reactor; and  
a second selection valve connected to the line and the exhaust pump.

6. The semiconductor thin film deposition apparatus of claim 3, wherein the process ozone transfer member comprises:

a first process valve connected to the main valve in parallel; and  
a process mass flow controller and a second process valve sequentially connected to the first process valve, wherein the process mass flow controller preferably controls the flow of ozone up to 500sccm.

7. The semiconductor thin film deposition apparatus of claim 3, wherein the thermal treatment ozone transfer member comprises:

a first thermal treatment valve connected to the main valve in parallel; and  
a thermal treatment mass flow controller and a second thermal treatment valve sequentially connected to the first thermal treatment valve, wherein the thermal treatment mass flow controller preferably controls the flow of ozone up to 20000 sccm.

8. The semiconductor thin film deposition apparatus of claim 2, wherein the excessive ozone control unit comprises an automatic pressure valve and an ozone remover which are installed on the line between the main valve and the ozone generator, and the automatic pressure valve is automatically

opened when the pressure of ozone is equal to or greater than a predetermined value, and the ozone remover removes ozone which has passed through the automatic pressure valve.

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9. The semiconductor thin film deposition apparatus of claim 8, wherein the excessive ozone control unit further comprises a valve for allowing/blocking the flow of ozone and a check valve for allowing ozone having a predetermined pressure or greater to flow only toward the ozone remover, the valve and the check valve being installed on the line between the main valve and the ozone remover.

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10. The semiconductor thin film deposition apparatus of claim 1, further comprising a heater for providing a temperature to perform thermal treatment on a wafer received in the reactor in the reactor and, preferably, wherein the heater provides the temperature in a range of 300 to 700 °C.

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11. The semiconductor thin film deposition apparatus of claim 1, wherein the inert gas is argon.

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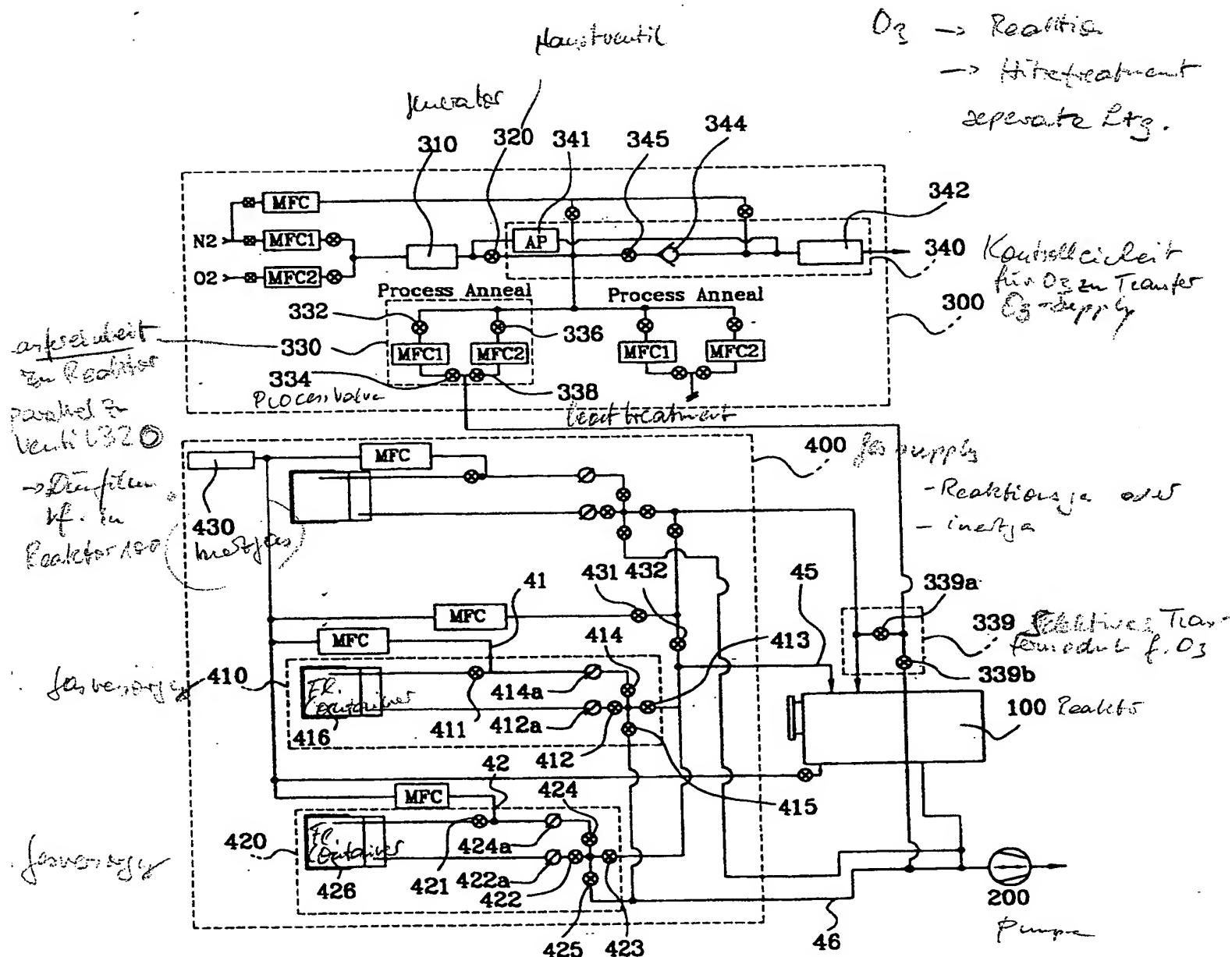
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FIG. 1



$O_3 + \text{Reaktion, o}$

[2a] 410, 420, 430 unikontrolliert betrieben



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Office

## EUROPEAN SEARCH REPORT

Application Number

EP 00 31 1218

DOCUMENTS CONSIDERED TO BE RELEVANT			
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<p>The present search report has been drawn up for all claims</p>			
Place of search	Date of completion of the search	Examiner	
THE HAGUE	16 March 2001	Ekhult, H	
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ..... & : member of the same patent family, corresponding document	
<small>EPO FORM 1803/01-82 (P04/001)</small>			

ANNEX TO THE EUROPEAN SEARCH REPORT  
ON EUROPEAN PATENT APPLICATION NO.

EP 00 31 1218

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16-03-2001

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EPO FORM P1059

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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I 411, 412, 413@: transfer gas tubes 41 pipe + 411 in 100 tubes + 12a, 412  
413, 45 (reactor line) Zusammen mit RG aus 416

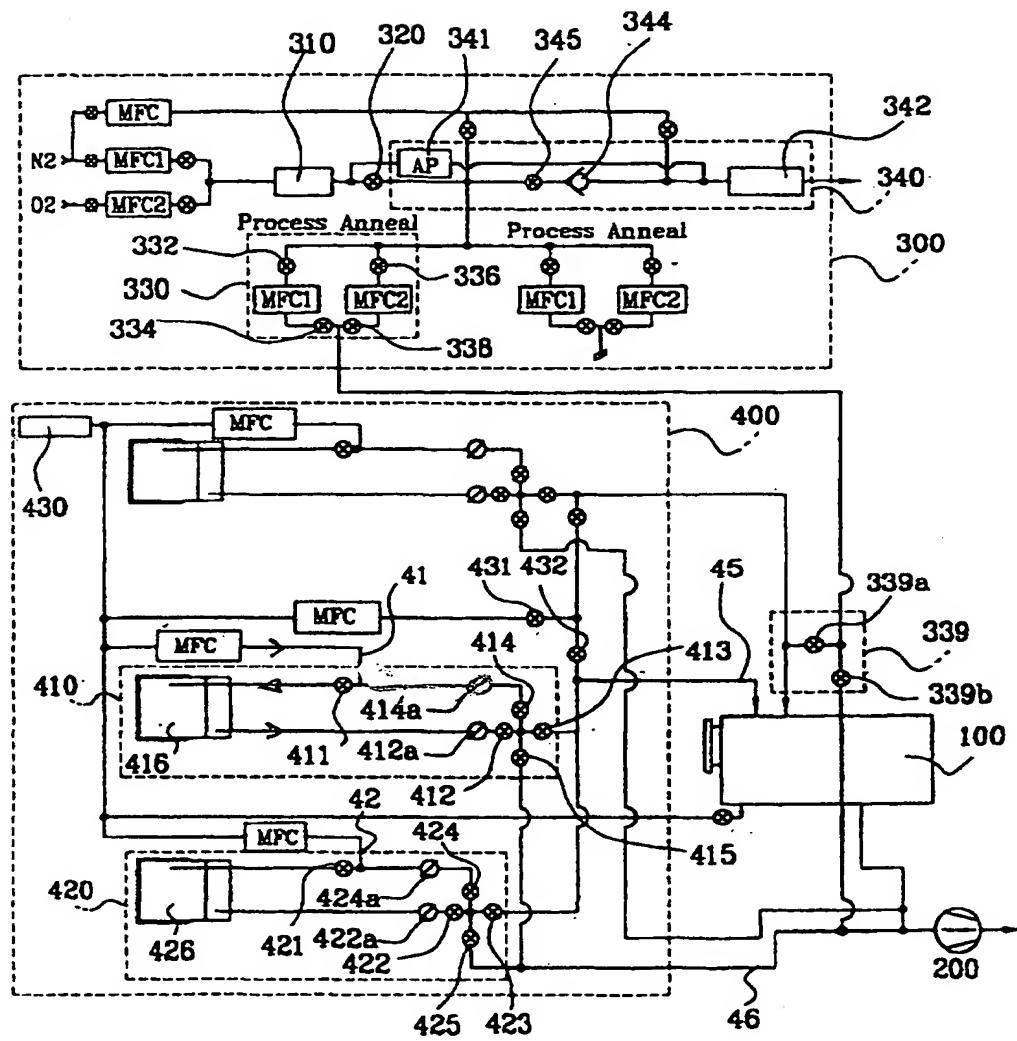
E25

invest gas into exhaust RG 416 in 100

EP 1 108 468 B1

III.

FIG. 1



1. Gunn-Diode, umfassend. einen, einen Gunn-Effekt auslösenden, aktiven Berreichen (2) und einen Injektor (4, 5a, 5b, 5c, 6), der Injektor (4, 5a, 5b, 5c, 6) der Gunn-Diode, umfasst. dadurch gekennzeichnet, dass in den aktiven Berreichen (2) der Gunn-Diode in jener zierten Elektronen umfasst. eine Energiediabassfitter (5a, 5b, 5c) für die eine Energiediabassfitter (5a, 5b, 5c) für die 2. Gunn-Diode nach Anspur 1, gekennzeichnet durch dadurch gekennzeichnet, dass in den aktiven Berreichen (2) der Gunn-Diode in jener zierten Elektronen umfasst. eine Resonanz-Tunnelldiode als Energiediabassfitter. 3. Gunn-Diode nach einem der vorhergeheenden Anspur- che, dadurch gekennzeichnet, dass der Injektor als Energiediabassfitter eine Dop- pelbarriere aus mindestens zweien wenigen Monolagen dicken und von einer durch eine Zwischenbeschicht (5b) getrennter, Schicht (5a, 5c) aufweist. 4. Gunn-Diode nach einem der vorhergeheenden Anspur- che, dadurch gekennzeichnet, dass zwischen dem aktiven Berreichen (2) und dem Energiefie- bandpassfitter (5a, 5b, 5c) eine Delta-dotierte Schicht (3) angeordnet ist.

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[26]

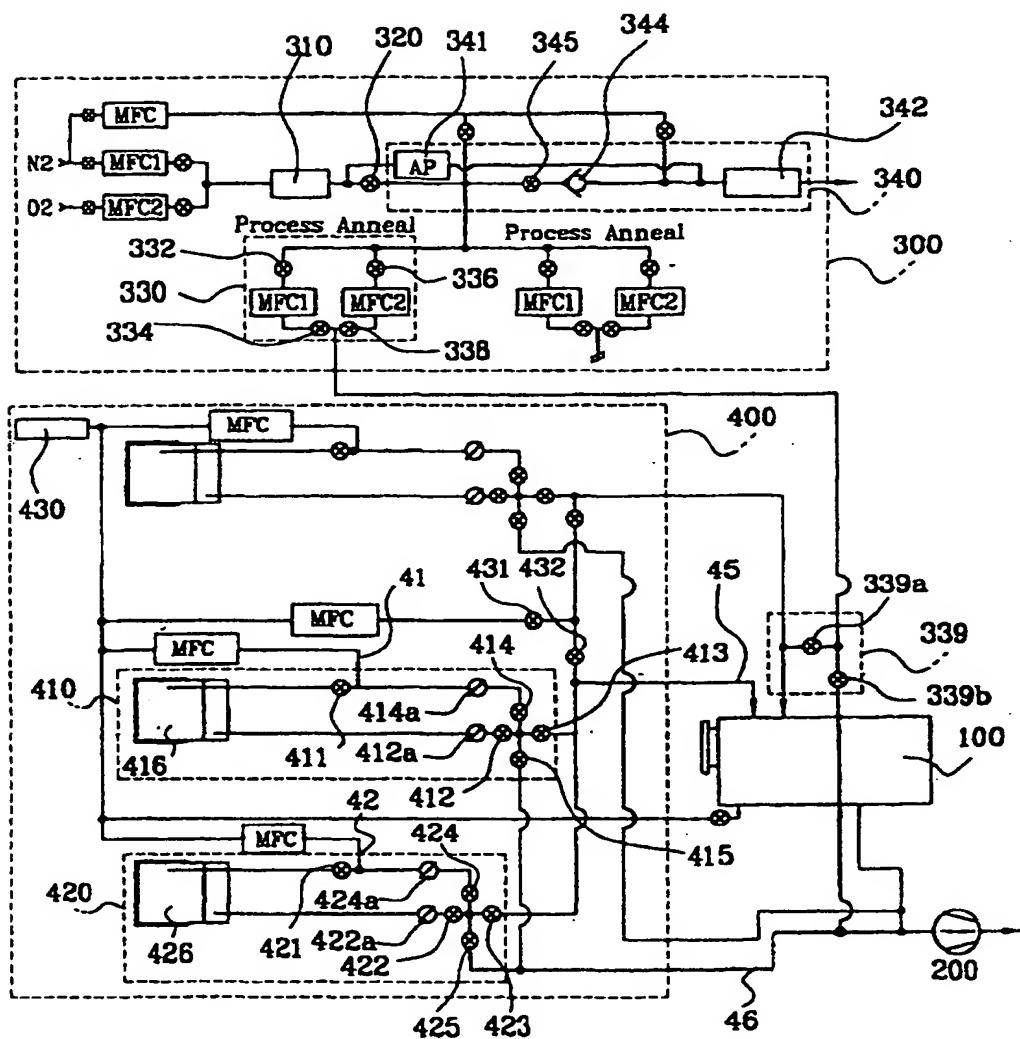
II 414, 415

carrier gas tubes 41 to outside  
filter 414a, 414, 415

EP 1 108 468 B1

exhaust line 46 to pump 200

FIG. 1



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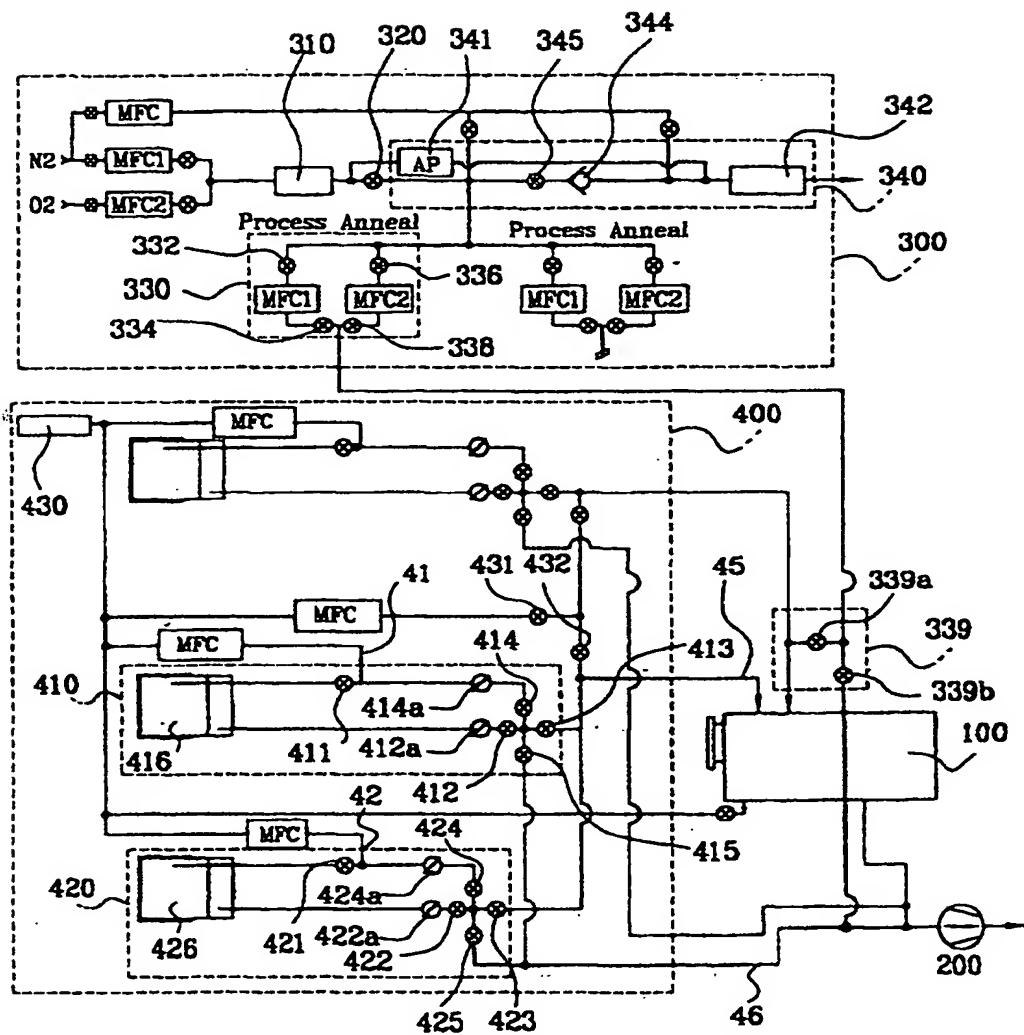
III [27]

intg's

new 431, 432 reactor line 45  
exhaust R6 in 100

EP 1 108 468 B1

FIG. 1



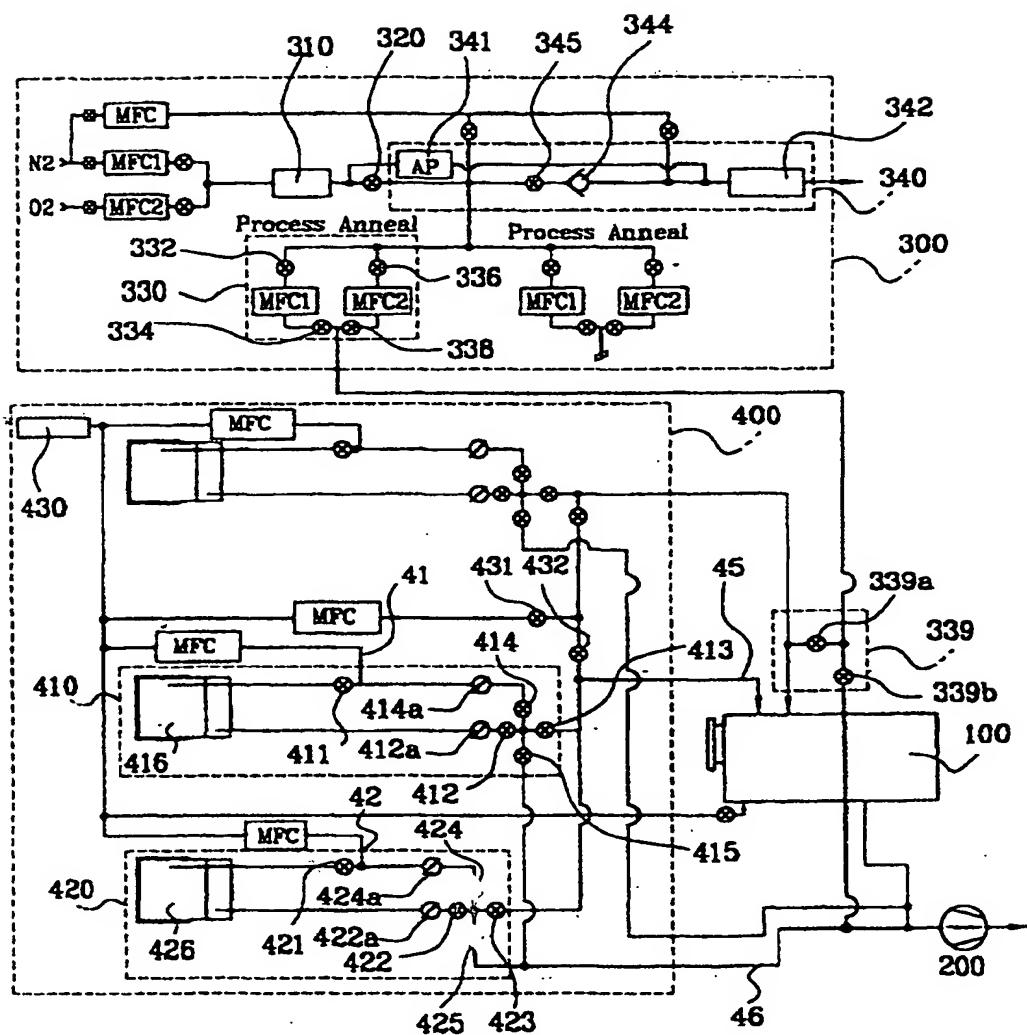
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IV R62 : 422a, 422, 423, 5.1, 45 sus. unit  
cartridges 42, 421

[28]

EP 1 108 468 B1

FIG. 1



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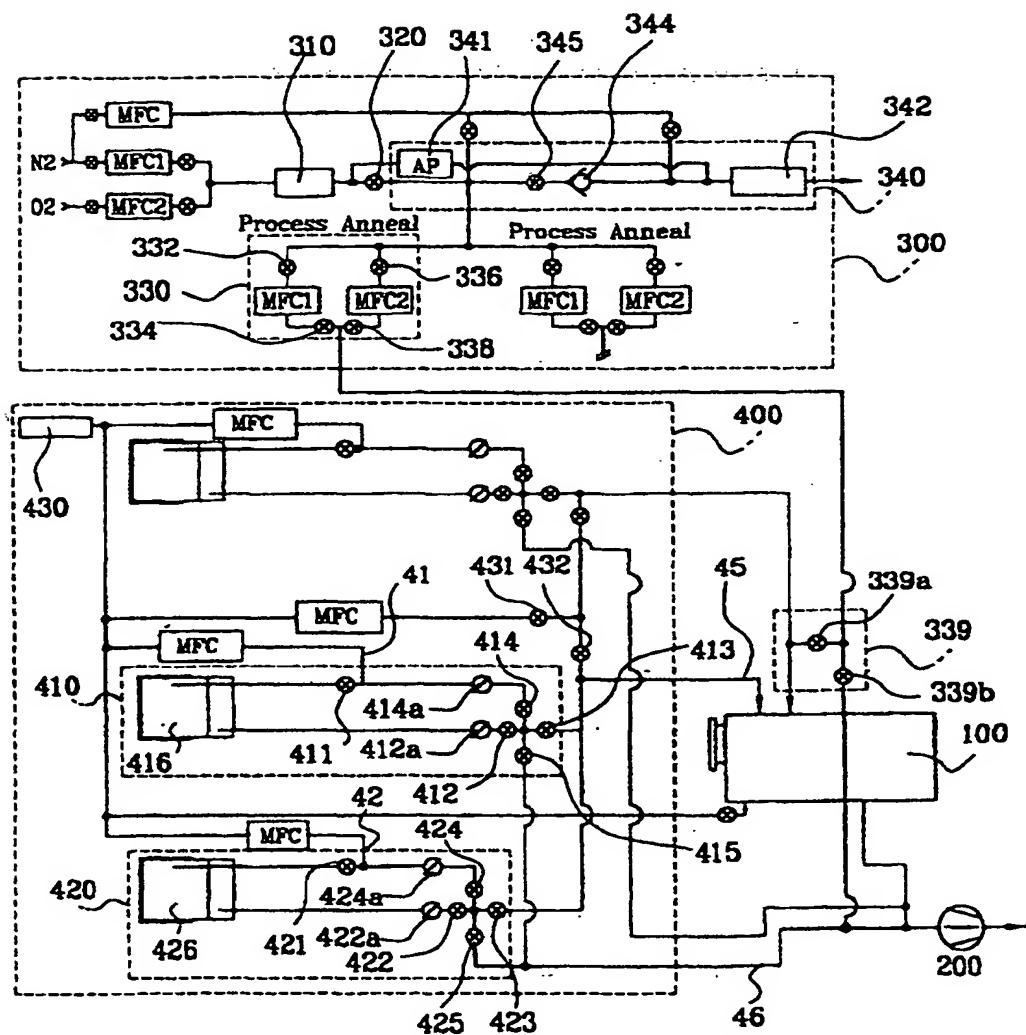
176) [28]

424, 425 c. g. exhaust

EP 1 108 468 B1

422a, 424 a : control of gas

FIG. 1



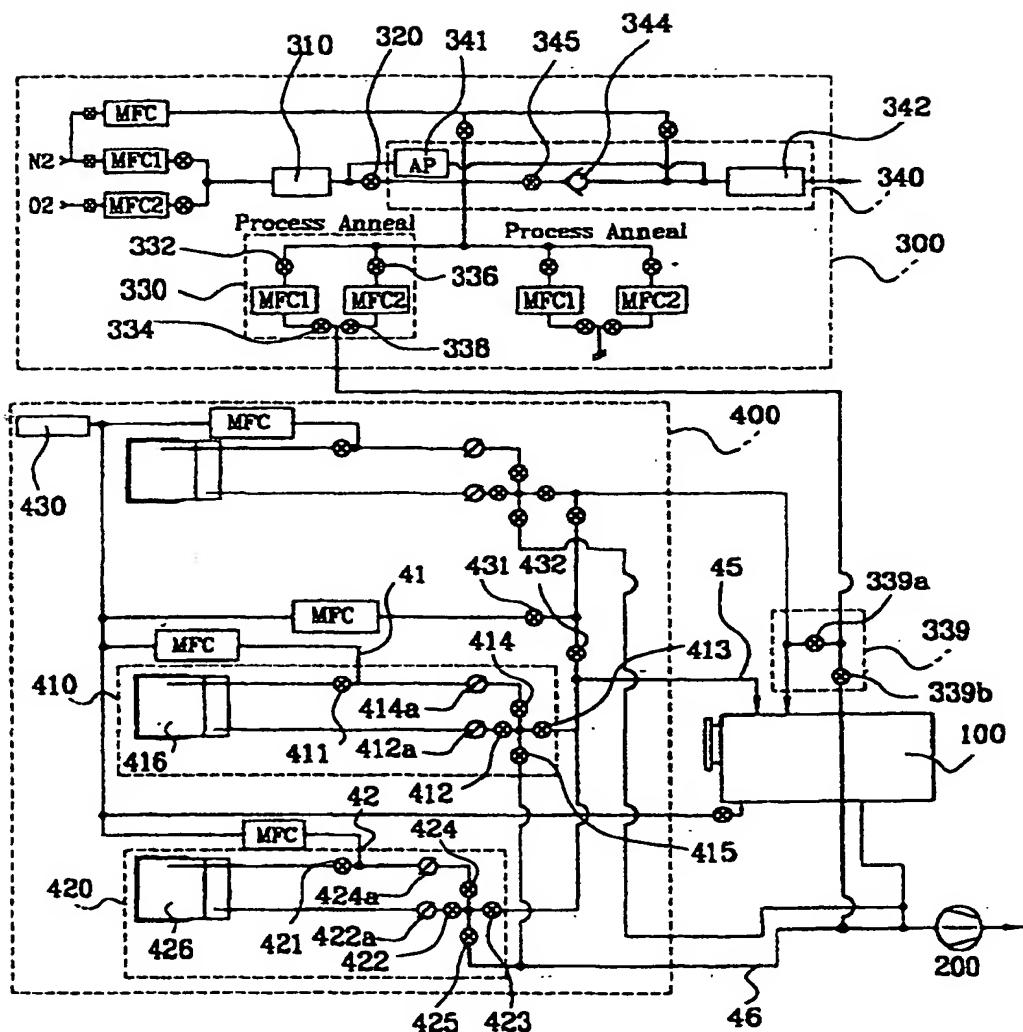
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VI [29]. first gas 431, 432, 45

EP 1 108 468 B1

exhausts reaction gas

FIG. 1



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(X)

32  
VI [29]

thermal treatment

03 : 310, 320, 336, 338, 334

After thermal treatment  
EP 1 108 468 B1

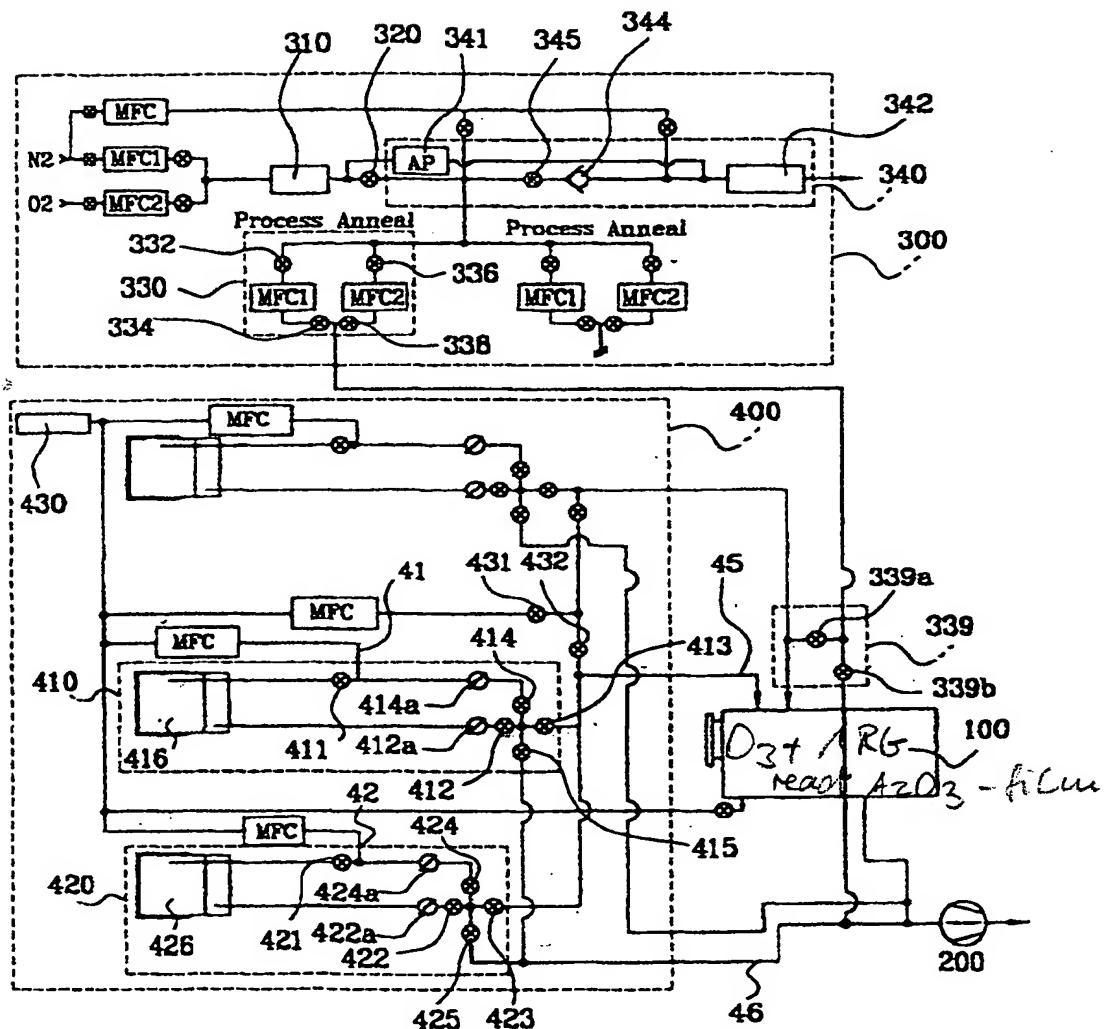
1. reglayer: 416, 412a, 412,  
413, 45 → 100

2. anneal w. t

FIG. 1

carrier gas

$\text{Ar}_2\text{O}_3$  deposition



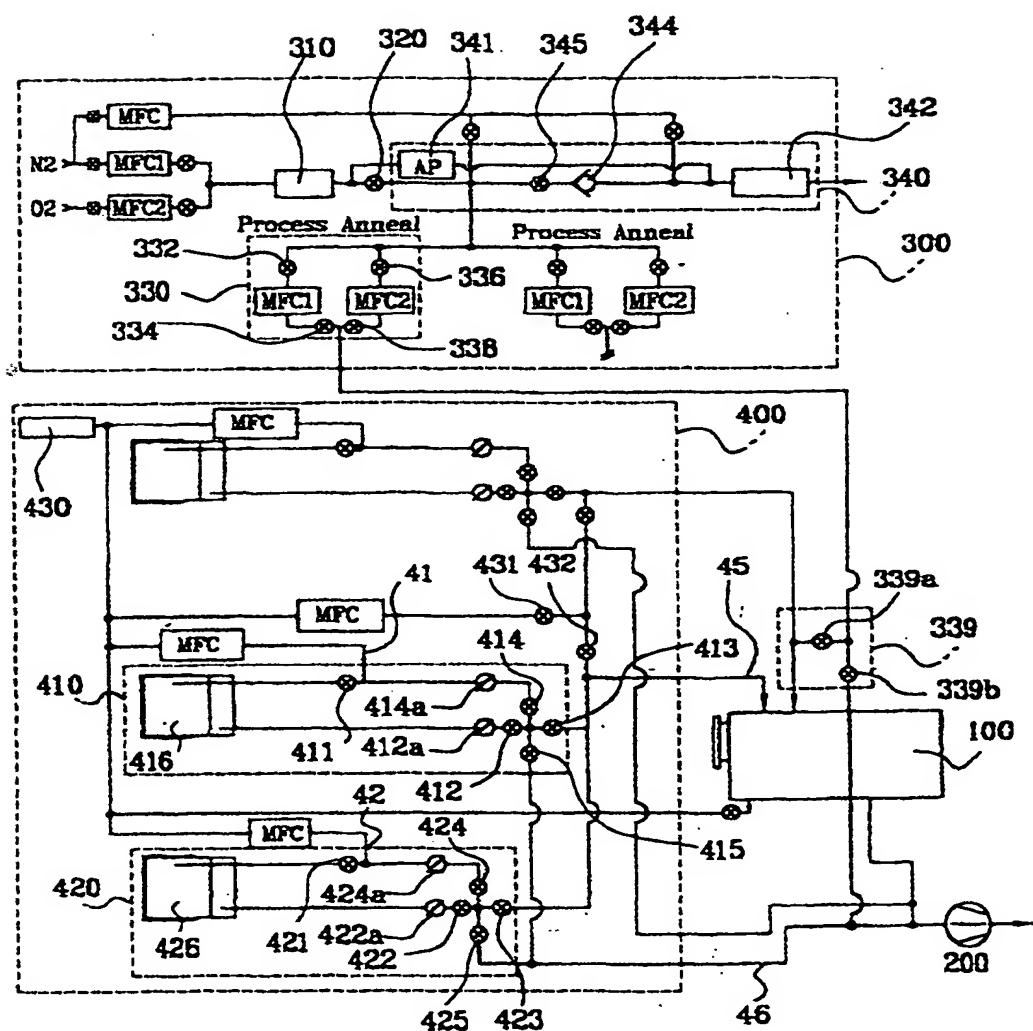
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88  
 VI [29]      Pwge : 431, 432, 433  
 [not for]

EP 1 108 468 B1

exlast O<sub>2</sub> + 1. R6

FIG. 1



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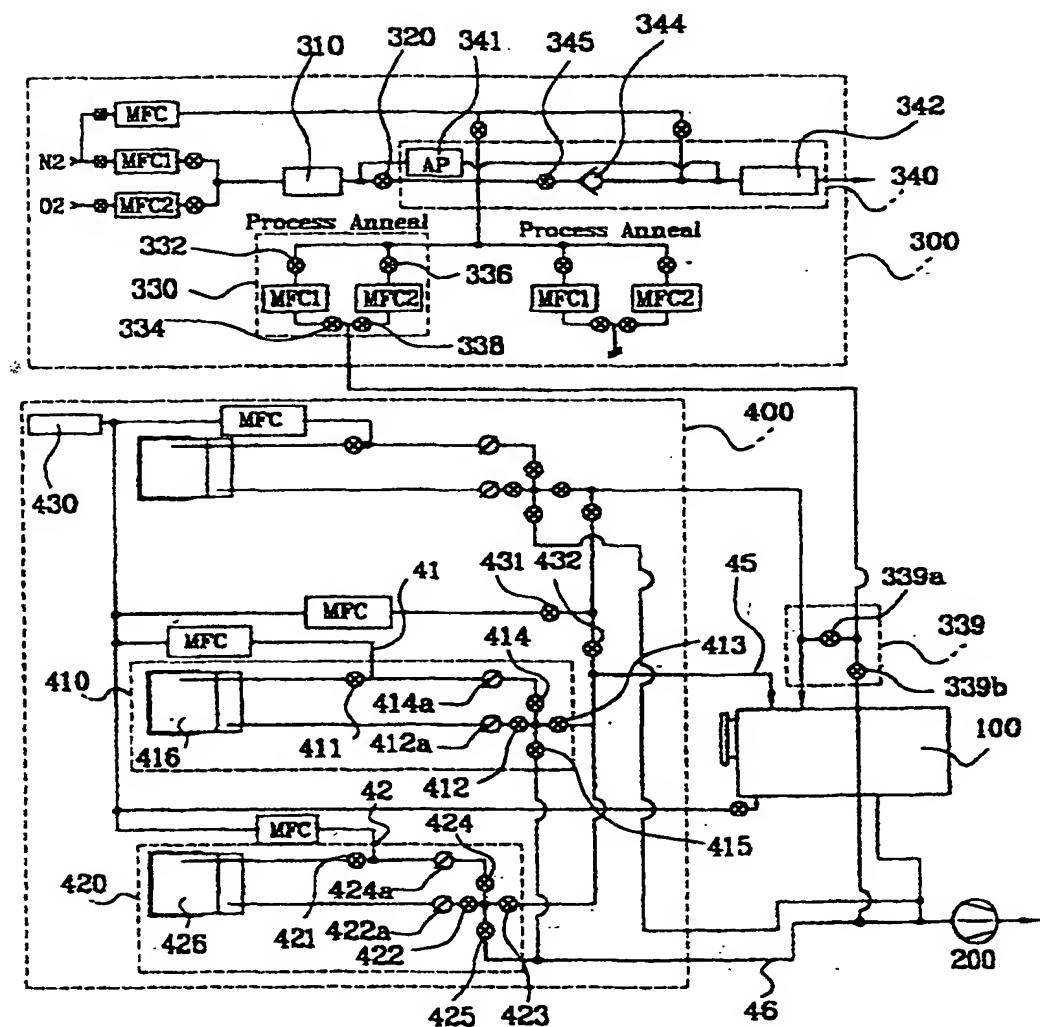
VI [2A] <sup>34</sup> deposition

Wic [31]+[32] in

EP 1 108 468 B1

VI

FIG. 1



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